RESEARCH AND IMPLEMENTATION OF 3D TRAINING SYSTEM FOR SUBSTATION SIMULATION

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ABSTRACT

In order to improve the ability of substation operators, the 3D training system using virtual technology is designed. It makes great sense to present the trainees with vivid scenes of the substation. Considering the diversity and complexity of substation equipment, the model should be carefully designed. In order to make the model flexible and reusable, model design can be decomposed into physical model design and electrical model design. Physical model focuses on the appearance and shape of the equipment, while the electrical model pays more attention to the behaviours. Physical models of the equipment must be designed elaborately according to its shape and make itself compatible with electrical model. The system can also exchange data with other system, such as online monitoring system. The system has deployed in an underground substation, and the time spend on model building has been greatly decreased.

INTRODUCTION

Substations have been playing a very important role in the power system. It is quite necessary to train the operators to promote their operations when they face emergencies [1, 2]. Due to the role that the substation plays in the power system, it is difficult to train operators with actual operation [3, 4].
With the development of 3D animation technology, it has been applied more and more in the simulation systems and training systems. It provides the trainees with very vivid scenes to make the training much more effective [5]. Ref. [6] used VRML to implement virtual substation.
In this paper, the 3D technology is applied in the training system, and Virtools is used to realize the 3D virtual reality. System framework is introduced and equipment modelling is described in detail. Then the data exchange performance between 3D system and other systems is explained. The data synchronization method is also introduced.

SYSTEM FRAMEWORK

The substation training system is made up of 3D platform, database and 2D platform. The 3D platform mainly contains the 3D training system and interface applications. The 3D training system is designed to provide vivid scenes of the substation. The interface applications are responsible for exchanging data between the 3D system and database, and database is used to share the data between the 3D system and the 2D systems. The 2D platform is introduced to fulfil the training system. Monitoring system and controlling system is included in the 2D platform.

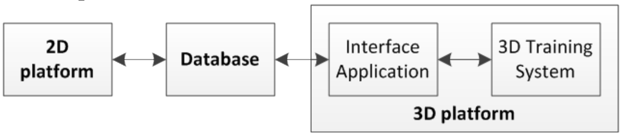

Figure 1: Substation training system framework

MODEL DESIGN

There are various kinds of equipment in the substation, and there are much more in underground substation, considering the auxiliary systems [7]. The equipment displayed in the 3D system can be decomposed into physical model and electrical model [8].
The physical model design pays more attention to present the equipment with its origin appearance and shape, while the electrical model design focuses on the interaction in 3D system, such as fault phenomenon and fault operation.

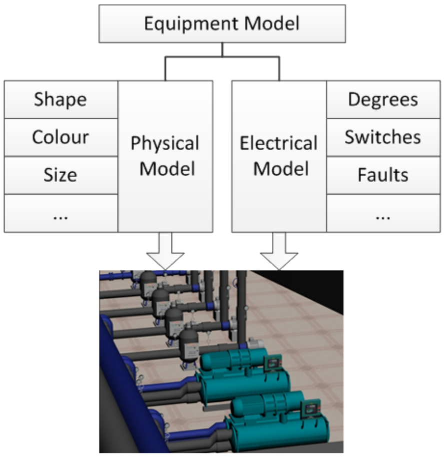

Figure 2: Model design of the equipment

Physical Model Design

3DsMax is introduced to draw the physical models and import the models into the 3D system. All the equipment models drawn in 3DsMax are made up of many tiny units, and dozens of units may just form one little part of the model. It is quite convenient to group the units and it saves much workload when creating action scripts in 3D system, as the 3D system can identify the groups and regard the units as a whole. In addition, model groups can be reused when drawing a similar type.

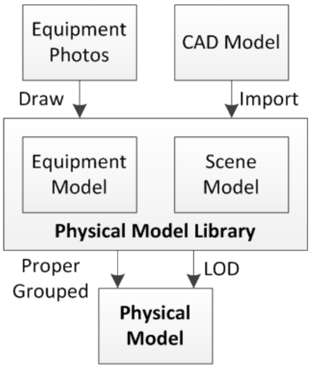

Figure 3: Physical model design

The physical model of the equipment is built according to its actual appearance and shape. With the help of the photos and the CAD drawings, the equipment can be drawn as vivid as possible. The simple equipment model can also be imported with the CAD drawing provided. Since the appearance or shape of the equipment may change when it breaks down, it is very important to group the units properly and build the units elaborately. Then these tiny units are able to act as required， when they need to change status according to the electrical information.

Scene model is another kind of physical model, and it focuses on the environment and space structures in the substation. A room or a floor can be called a scene, and a lot of equipment may lie in the same scene. However, the scenes and the equipment can't be treated in the same way. It's better to draw them separately, as scene models should be rendered all the time. Actually the 3D system renders all the models that have been loaded, although some of them may be sheltered by other models. It wastes a lot of graphic resources to render the equipment models out of sight. Thus it is smart to load the models separately. The equipment models that come into sight should be loaded, when the operator walks near. Besides, it is quite important to take advantage of the doors. The equipment models inside the room should only be loaded when the door is open or the operator is in the same scene. This also saves resources when the operator walks in the corridor, as the doors aside can be closed. In addition, levels of detail (LOD) can also be introduced to save resources.

Electrical Model Design

The electrical model reflects the behaviours of the equipment. Although there are many different kinds of equipment and their behaviours may be totally different, their electrical models are of the same structure. The electrical model consists of data module, logical module and action module, and all of them are mainly made up of action scripts. The structure of the electrical model is shown in figure 4.

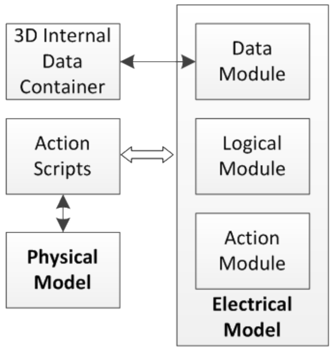

Figure 4: Electrical model design

Data module stores all the current information of the equipment, such as the status data. This module must keep synchronous with the database. In addition, an offline package is also stored in the module to ensure the normal display when there is no connection to the database. Logical module is responsible for operation and status judgement. Once operation is carried out or there're some changes in the system, the logical module will trace the interaction and the changes. Then analysis is made to decide the status of the equipment and its manifestation. Action module is responsible for the interaction between the trainee and the equipment. It tells the equipment how to react when operation is carried out or the equipment changes its status.

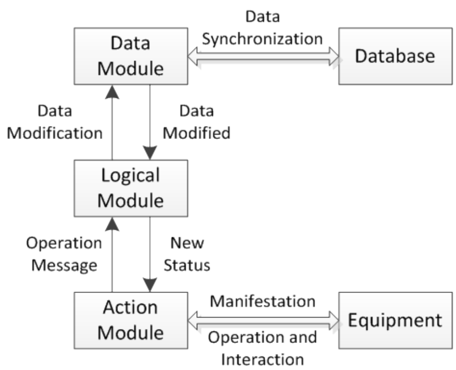

Figure 5: Structure diagram of equipment interaction in the 3D system

If the trainee needs to open the breaker of a branch, the button on the control cabinet should be pushed. Then the action module will identify the operation, and the message that the button is pushed is sent to the logical module. The logical module reads the data interrelated with the operation. If the control switch is turned to "remote", the operation will be rejected and display a warning to the trainee. If the control switch is turned to "local", logical module will modify the data of the breaker. After the modification, the data module will inform the logical module back to logical module. Then new status message is sent to action module to tell the equipment how to react.

DATA EXCHANGE

The 3D system is very important in the training system, and it is quite necessary to exchange data between different systems. Interface application is introduced to realize the data exchange between the database and the 3D system.

The data connection can be divided into two steps. First, the 3D system will check the connection to the interface application. Then the interface application will try to connect the database using ODBC. If both of the connections succeed, the data change between the 3D system and the database can be realized. Otherwise, a warning will be displayed to tell the trainee that there is something wrong with the connection.

The failing counter is triggered, when the interface application fails to connect to the database. If the number exceeds during a short time, a severe warning is displayed. Because this kind of failure usually results from illegal system configuration or it means that the system is running abnormally. The database connection procedure is showed in Fig.6.

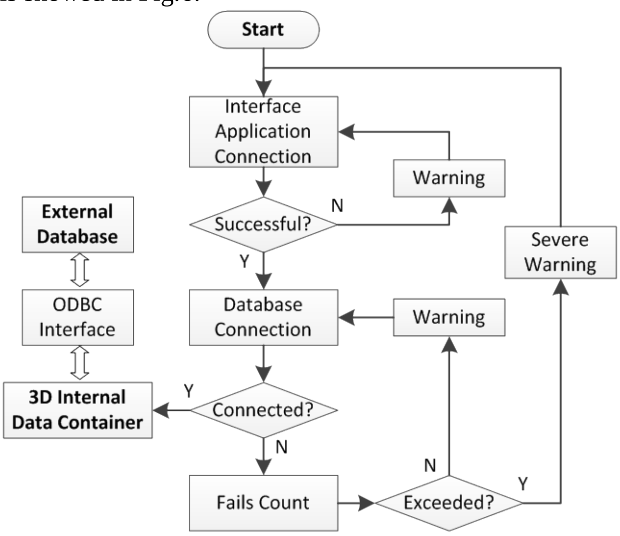

Figure 6: Database connection procedure of the 3D system

DATA SYNCHRONIZATION

When the 3D system is connected to the database, the data in the database will be read by the 3D system. Then the 3D system is synchronized with the other systems. If an event occurs in other system, the new data will be updated into the database, and the 3D system will read the new data later. However, when different systems try to update data of the same equipment at the same time, they will conflict with each other and data will be overwritten randomly. Setting priority is a good way to solve this problem. An application can't update the data when another application has locked the data with higher priority by flag.

When the trainees are training themselves in the 3D system, their operation has the highest priority. It means that new data from the 3D system will be always written into the database, when there are conflicts.

The 3D system reads from database every 3 seconds. Then the 3D system will inform the equipment within 3 seconds after other systems update new data into the database. Similarly, the data module of the equipment will read data from the 3D data container every 3 seconds. On the other hand, when the trainees take operation in the 3D system, if the status of the equipment is to be changed, the new status will be written into the 3D data container.

Since 3D system is very special, it's able to reflect the physical conditions of the equipment and the substation, which can't be displayed in other systems. For example, the tank is broken. In fact, there are some differences between the 3D data container and the database. They have intersections between them and both of them have some other information separately. So, there is no need to synchronize all the new status written to the 3D data container into the database. Only the status concerned by the other systems will be updated to the database.

The diagram of the data synchronization is shown in figure 7.

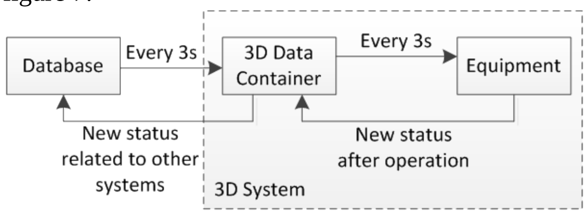

Figure 7: Diagram of data synchronization between the 3D system and database

CONCLUSIONS

The 3D virtual training system has been deployed in some 500kV underground substation in Shanghai. The electrical system and the auxiliary system are both constructed in the 3D system. The system runs stable and smoothly, and it's able to provides the trainees with vivid fault phenomena. The operation in one system can be well reflected in the other system at the same time. The training system has played an important role in improving the ability of operators in substation.

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